Improving the Forecasting of High Shear, Low CAPE Severe Weather Environments

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Research to Operations Webinar
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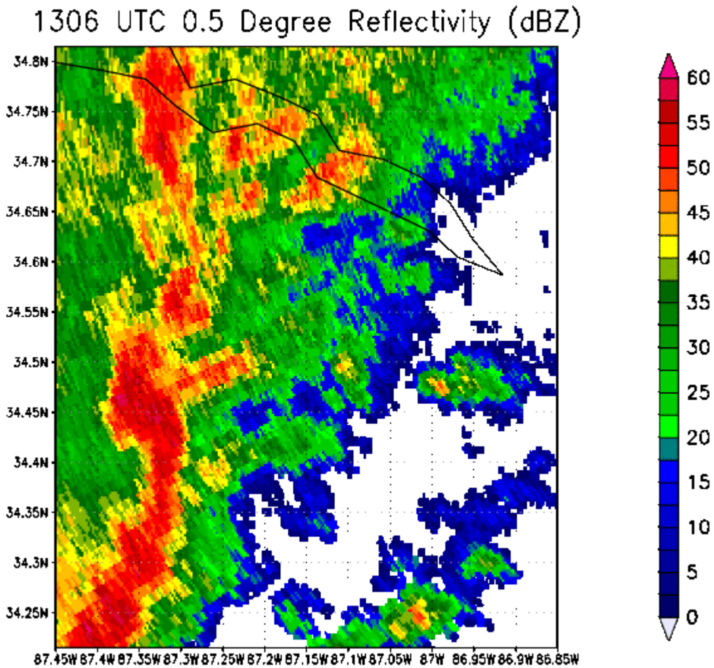
CIMMSE Collaboration for Improved Meteorology in the Mid-Atlantic and Southeast
Academic, operational, and government partners working together to improve meteorology

NC STATE UNIVERSITY

Background

- Subset of Schneider et al. (2006)'s second "key subclass" of severe weather
  - MLCAPE < 1000 J/kg
  - 0-6 km shear ≥ 18 m/s
  - 0-1 km shear ≥ 10 m/s
  - MLLCL < 1000 m
- "Low-CAPE strong deep layer shear conditions are associated with ***54 percent*** of the strong-violent tornado subset."
- Tornadoes in HSLC environments are among the most often missed in SPC tornado watches (Dean and Schneider 2008; 2012)


1306 UTC 0.5 Degree Reflectivity (dBZ)
34.8N
34.75N
34.7N
34.65N
34.6N
34.55N
34.5N
34.45N
34.4N
34.35N
34.3N
34.25N
87.45W 87.4W 87.35W 87.3W 87.25W 87.2W 87.15W 87.1W 87.05W 87W 86.95W 86.9W 86.85W
60
55
50
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40
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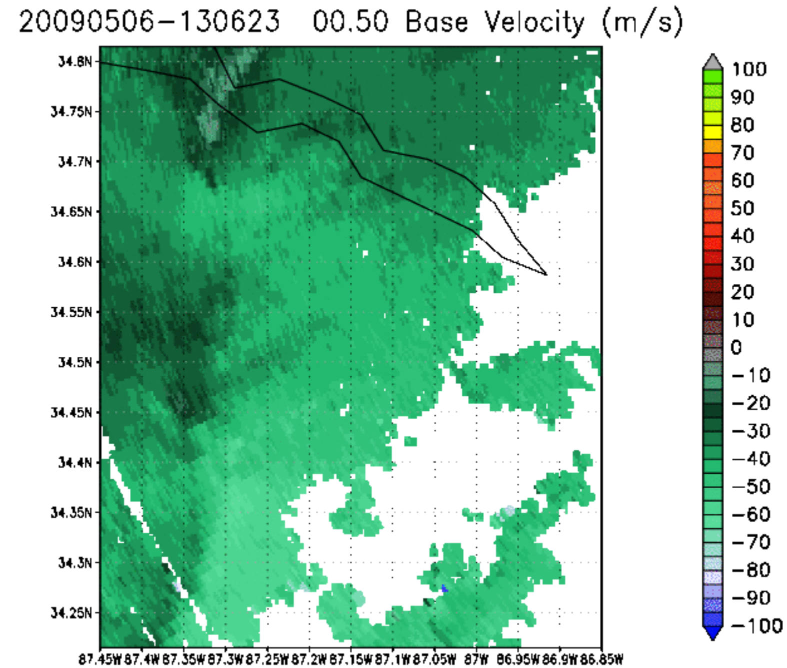
20090506-130623 00.50 Base Velocity (m/s)
34.8N
34.75N
34.7N
34.65N
34.6N
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34.5N
34.45N
34.4N
34.35N
34.3N
34.25N
87.45W 87.4W 87.35W 87.3W 87.25W 87.2W 87.15W 87.1W 87.05W 87W 86.95W 86.9W 86.85W
100
90
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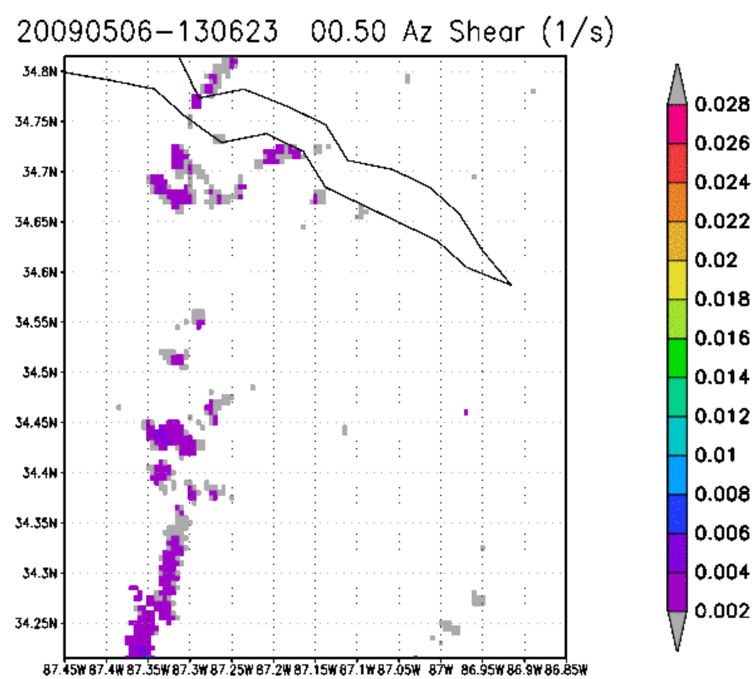

20090506-130623 00.50 Az Shear (1/s)
34.8N
34.75N
34.7N
34.65N
34.6N
34.55N
34.5N
34.45N
34.4N
34.35N
34.3N
34.25N
87.45W 87.4W 87.35W 87.3W 87.25W 87.2W 87.15W 87.1W 87.05W 87W 86.95W 86.9W 86.85W
0.028
0.026
0.024
0.022
0.02
0.018
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002

Learning Objectives

1. Improve the forecasting of HSLC significant severe environments

- Introduce new composite parameter (SHERB, **S**evere **H**azards in **E**nvironments with **R**educed **B**uoyancy parameter)
- Show benefits of the SHERB over "traditional" composite parameters for "low LCL" HSLC environments

Learning Objectives

2. Improve warning decision making in HSLC significant severe environments

- Examine potential of discriminating between tornadic and non-tornadic mesovortices.
- Identify radar-observed differences in tornadic mesocyclones vs. tornadic QLCS mesovortices.
- Recognize the limitations of reflectivity signatures as a WDM tool in HSLC environments.

Background

- "High" shear
  - 0-6 km layer
  - ≥ 35 knots (18 m/s)

HSLC

- "Low" CAPE
  - Surface-based parcel
  - ≤ 500 J/kg

- Null definition
- Used archived SPC Mesoanalysis fields

Developing a New Forecasting Parameter

- Most conventional composite parameters rely on high CAPE for optimization and may not adequately assess the threat in HSLC environments.

- Employed a statistical, eyes wide open approach

- What environmental parameters have highest True Skill Statistic (TSS) discriminating between HSLC significant severe reports and nulls?

- Focused on detecting favorable environments, not forecasting convection

New Forecasting Parameter

- Results show the product of the low and mid-level lapse rates and wind/shear magnitudes are the most skillful

Severe Hazards In Environments with Reduced Buoyancy (SHERB)

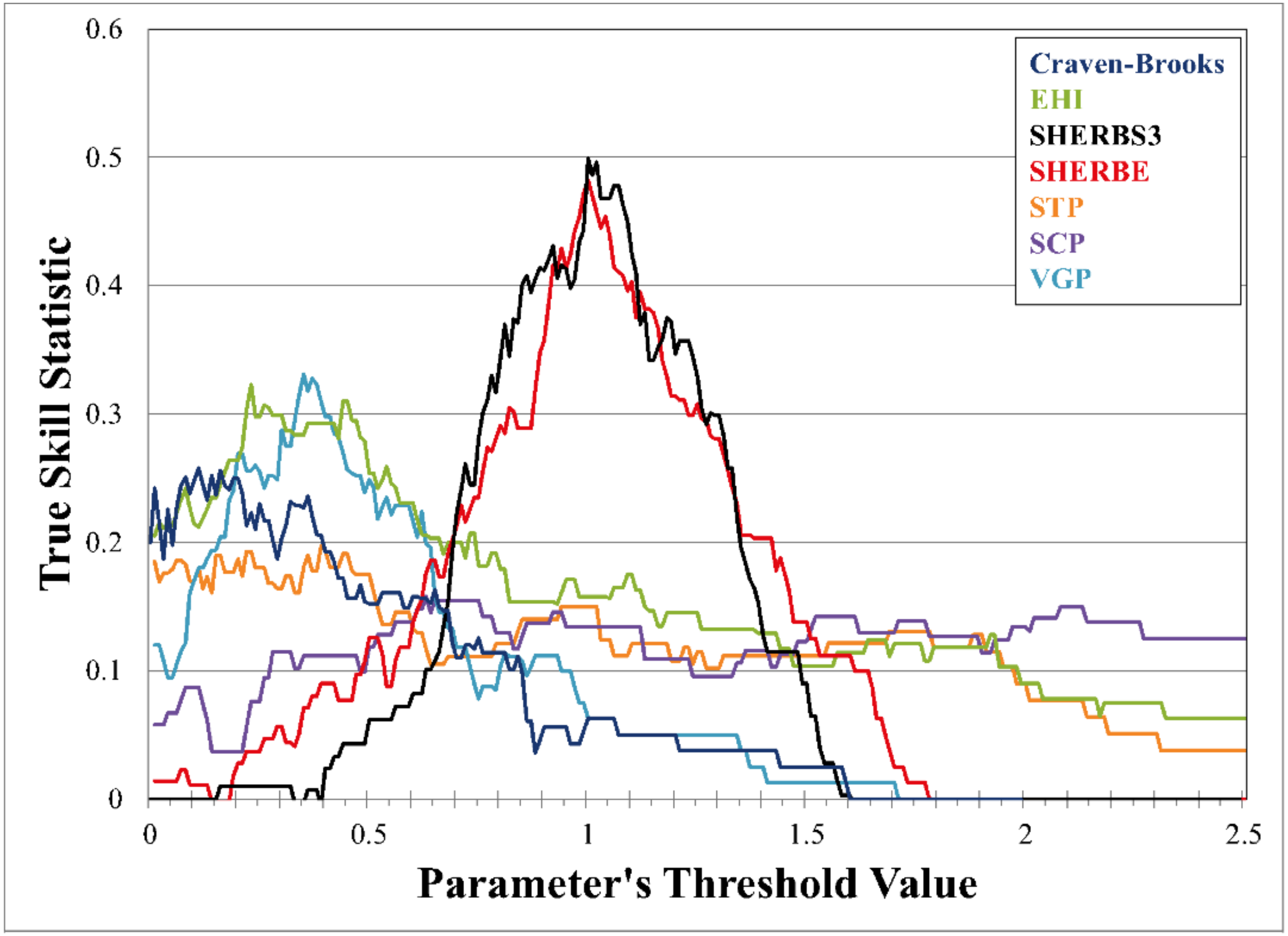
$$\textbf{SHERBS3} = \frac{(0\text{–}3\ km\ shear\ magnitude)}{26\ ms^{-1}}\ X\ \frac{(0\text{–}3\ km\ lapse\ rate)}{5.2\ K\ km^{-1}}\ X\ \frac{(700\text{–}500\ mb\ lapse\ rate)}{5.6\ K\ km^{-1}}$$

(0-3 km Shear Version)

$$\textbf{SHERBE} = \frac{(Effective\ shear\ magnitude)}{27\ ms^{-1}}\ X\ \frac{(0\text{–}3\ km\ lapse\ rate)}{5.2\ K\ km^{-1}}\ X\ \frac{(700\text{–}500\ mb\ lapse\ rate)}{5.6\ K\ km^{-1}}$$

(Effective Shear Version)

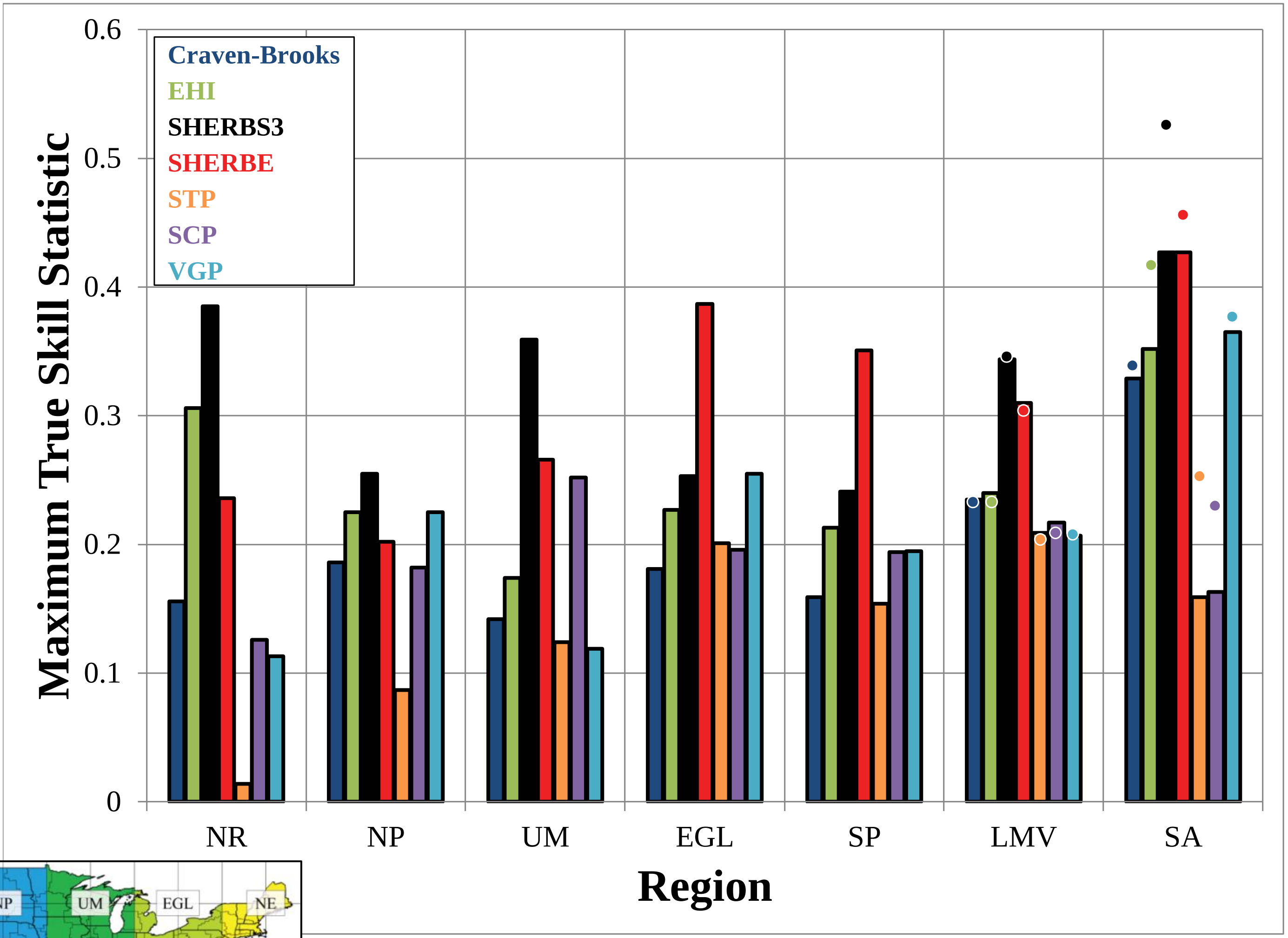
TSS of Composite Parameters for CSTAR Domain

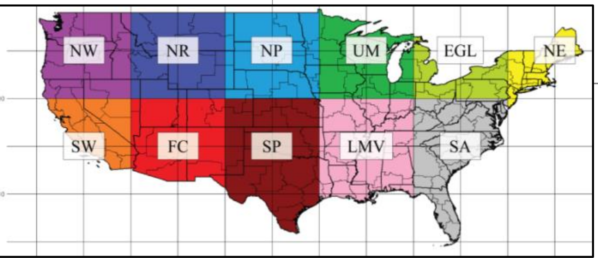


Development Dataset

*Note: Craven-Brooks and VGP scaled to fit x-axis

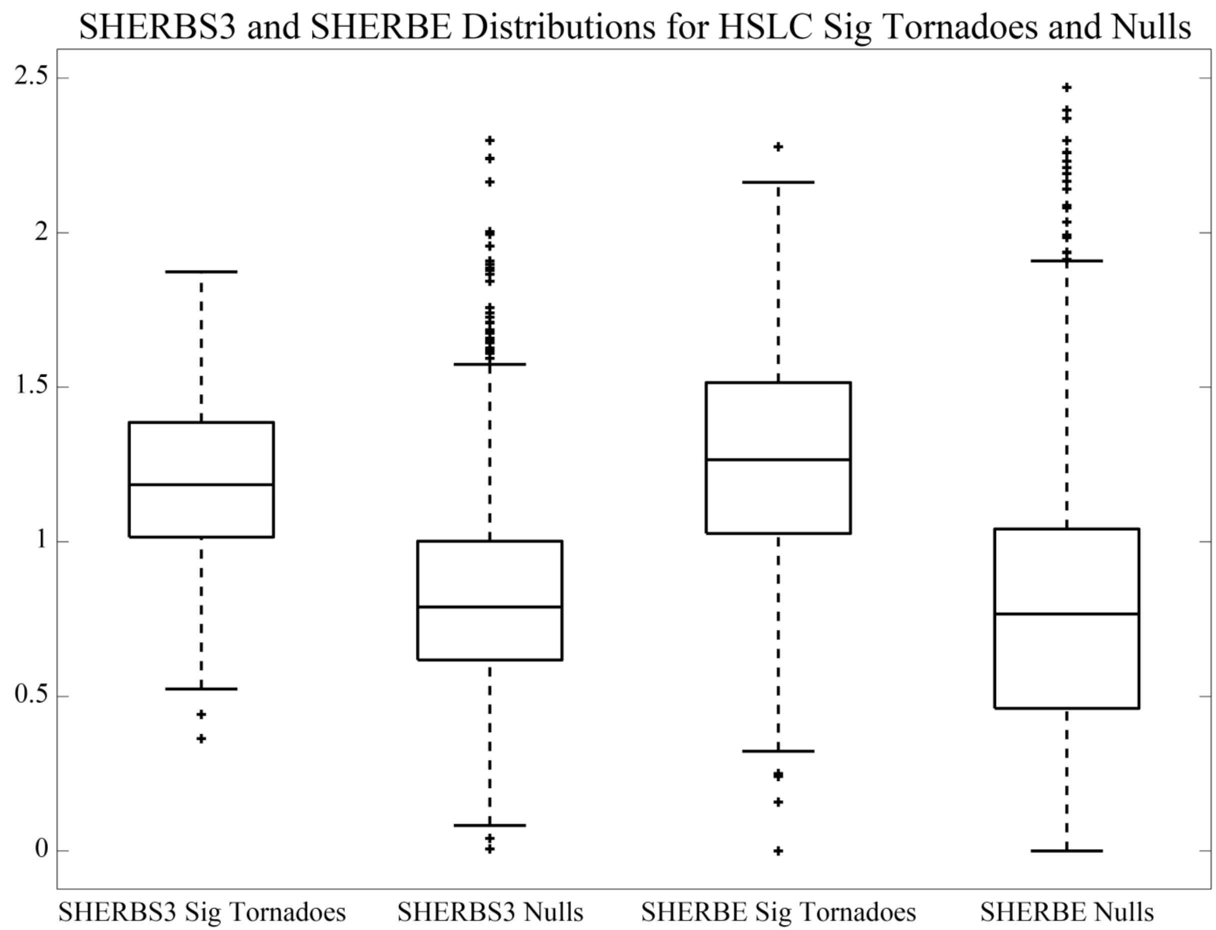
Maximum TSS of Composite Parameters by Geographic Region





Verification Dataset

New Forecasting Parameter



Verification Dataset

SHERB's Added Value

- Other parameters may show skill in identifying significant severe HSLC events at various thresholds, but the SHERBS3 and SHERBE are optimized for these events at a value of 1.

- SHERBS3 is perhaps the best all-around parameter for HSLC environments, especially in cases when the LCL is low.

- SHERBS3 is preferred in HSLC significant tornado events in the South Atlantic (SA) and Lower Mississippi Valley (LMV)

- Approximately 50% of HSLC significant severe reports (75% of significant tornadoes) in verification dataset occurred with SHERBS3/E ≥ 1; only ~25% of nulls occurred with SHERBS3/E ≥ 1

SHERBS3 Availability for Forecasters

- AWIPS-1 Volume Browser addition code & instructions

https://collaborate.nws.noaa.gov/trac/nwsscp/wiki/AppsAwips/Sherb
(AWIPS-2 code under development)

- AWIPS-1 and AWIPS-2 GFE tool coding & instructions

https://collaborate.nws.noaa.gov/trac/nwsscp/wiki/Gfe/Smarttools/Sherb

- Real-time SHERB plots from NC State

Real-time RAP – http://storms.meas.ncsu.edu/users/mdparker/rap
Real-time NAM – http://storms.meas.ncsu.edu/users/mdparker/nam
Real-time GFS – http://storms.meas.ncsu.edu/users/mdparker/gfs

- SPC SHERB mesoscale analysis plots

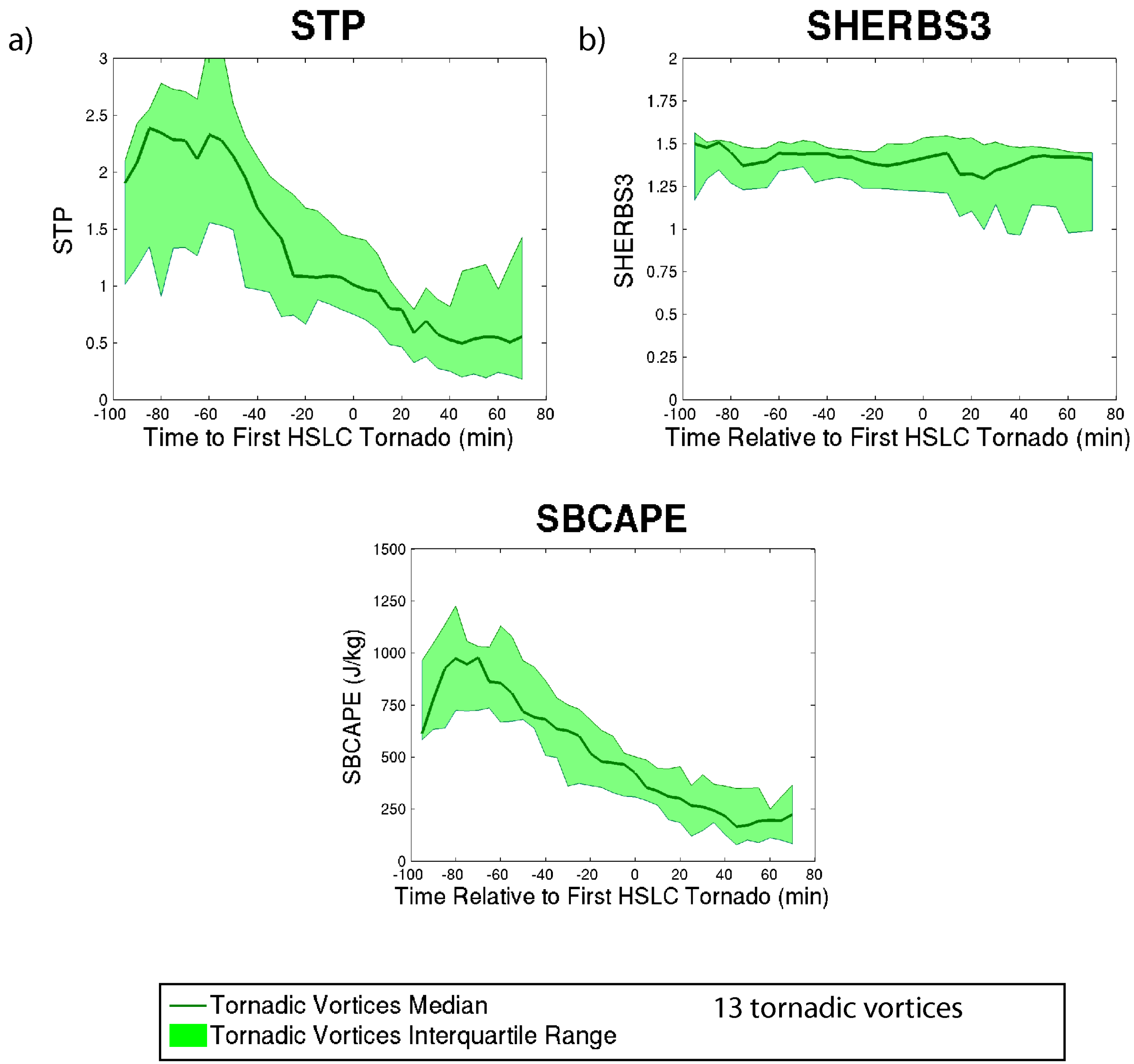
We hope to have some news about this soon.

- SHERB is expected to be added to Bufkit in an upcoming release

- Plots of SHERB on the HRRR web site

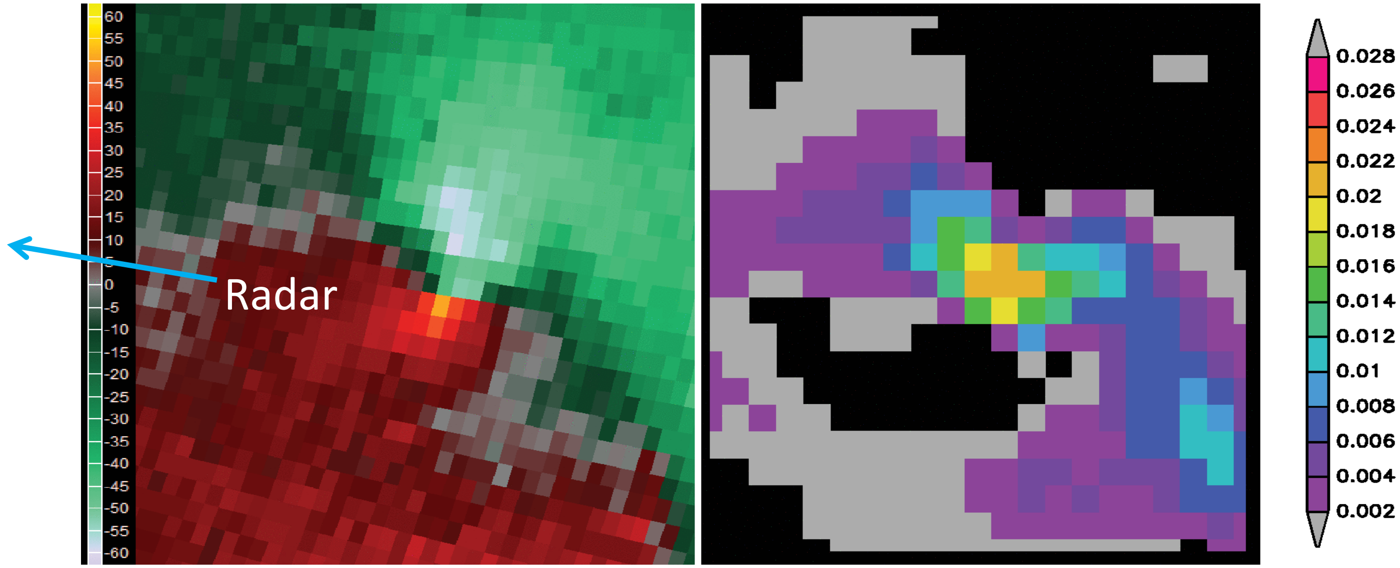
Collaborating with HRRR developers on this possibility.

Tornadic Vortices Originating in a Higher CAPE Environment



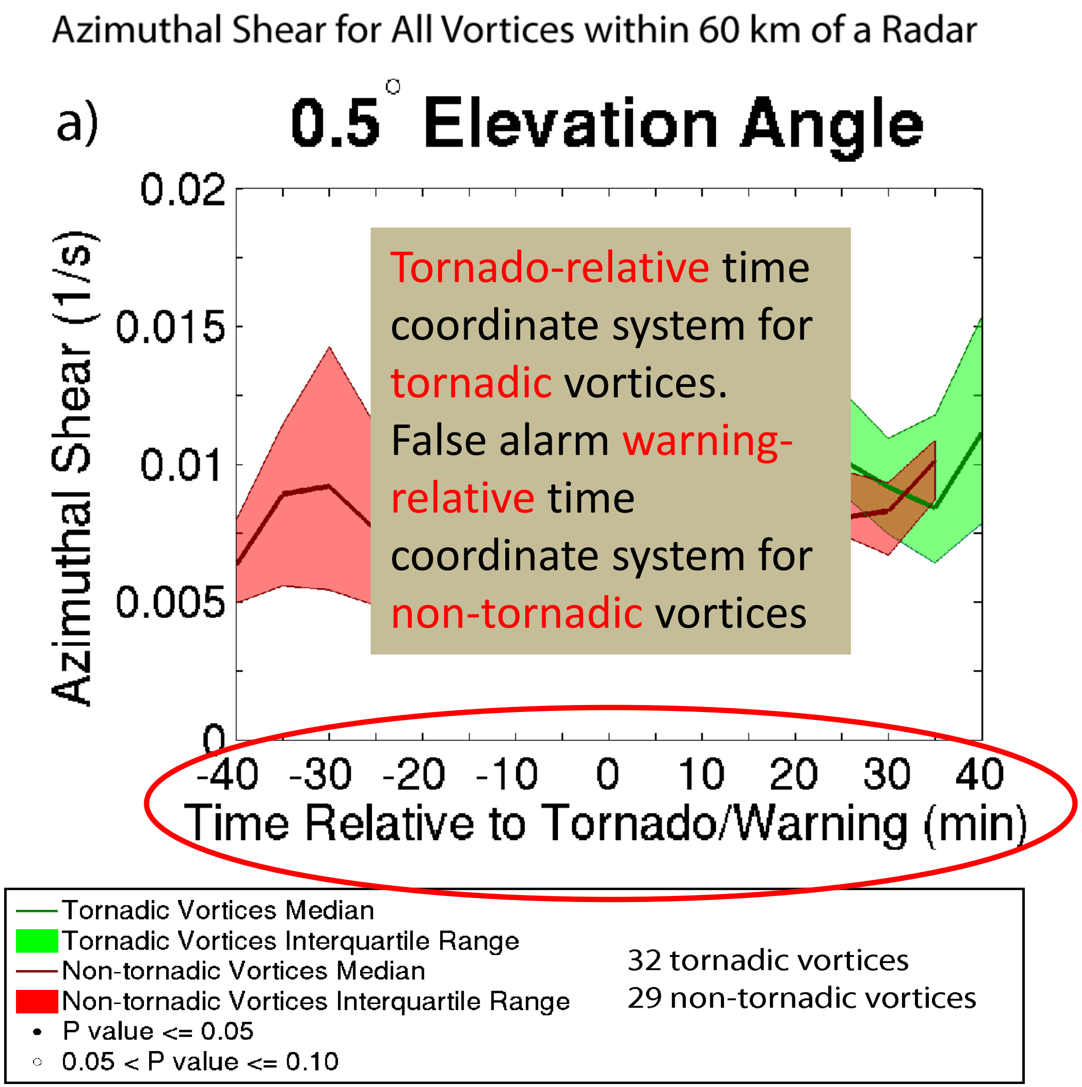
Radar Based Climatology Methods

- Tornadic and non-tornadic vortices were identified and tracked using radar azimuthal shear (A.S.) product (NSSL/OU).
- Non-tornadic vortices defined as those prompting Tornado Warning (TOR) false alarms
- A.S. used to quantify the strength of radar-observed rotation in tornadic and non-tornadic mesocyclones/mesovortices

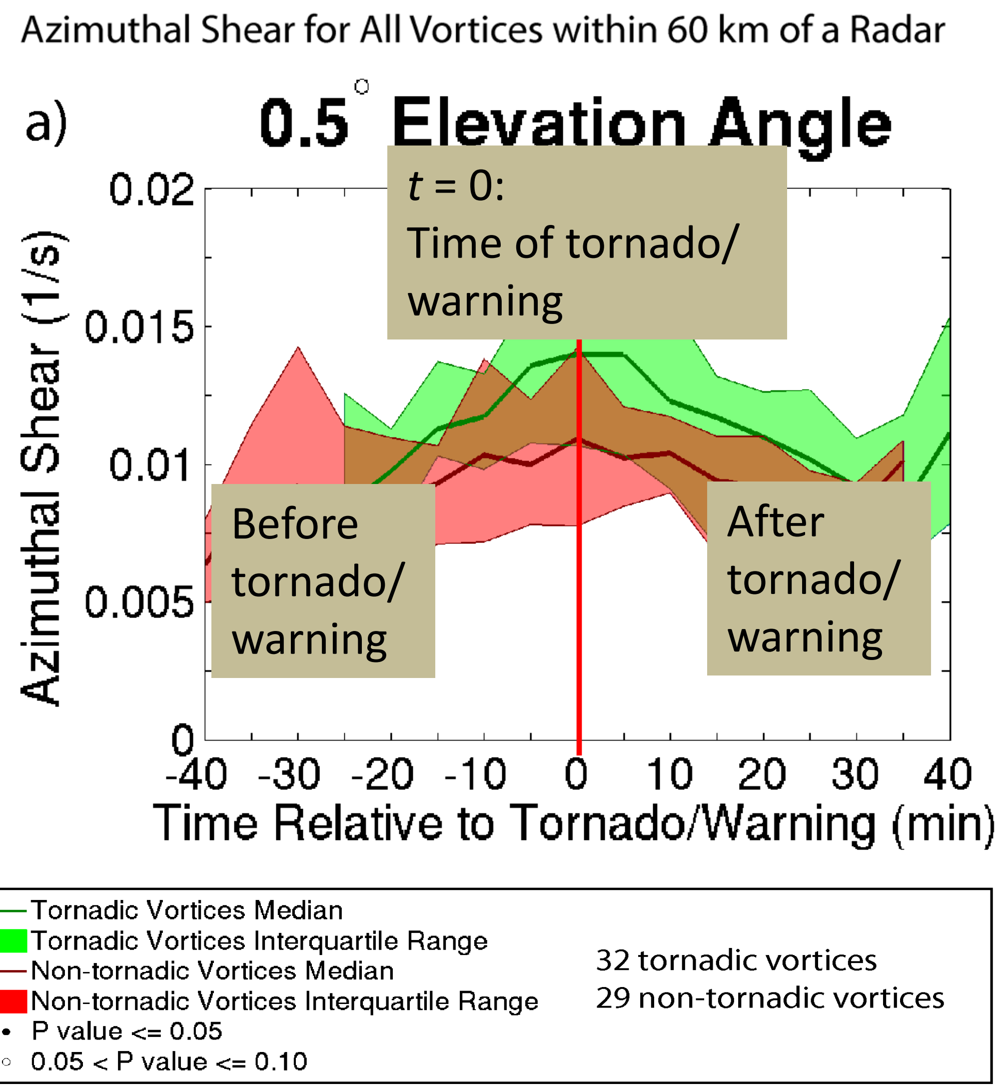


Radial velocity (kts) Azimuthal shear (s^{-1})

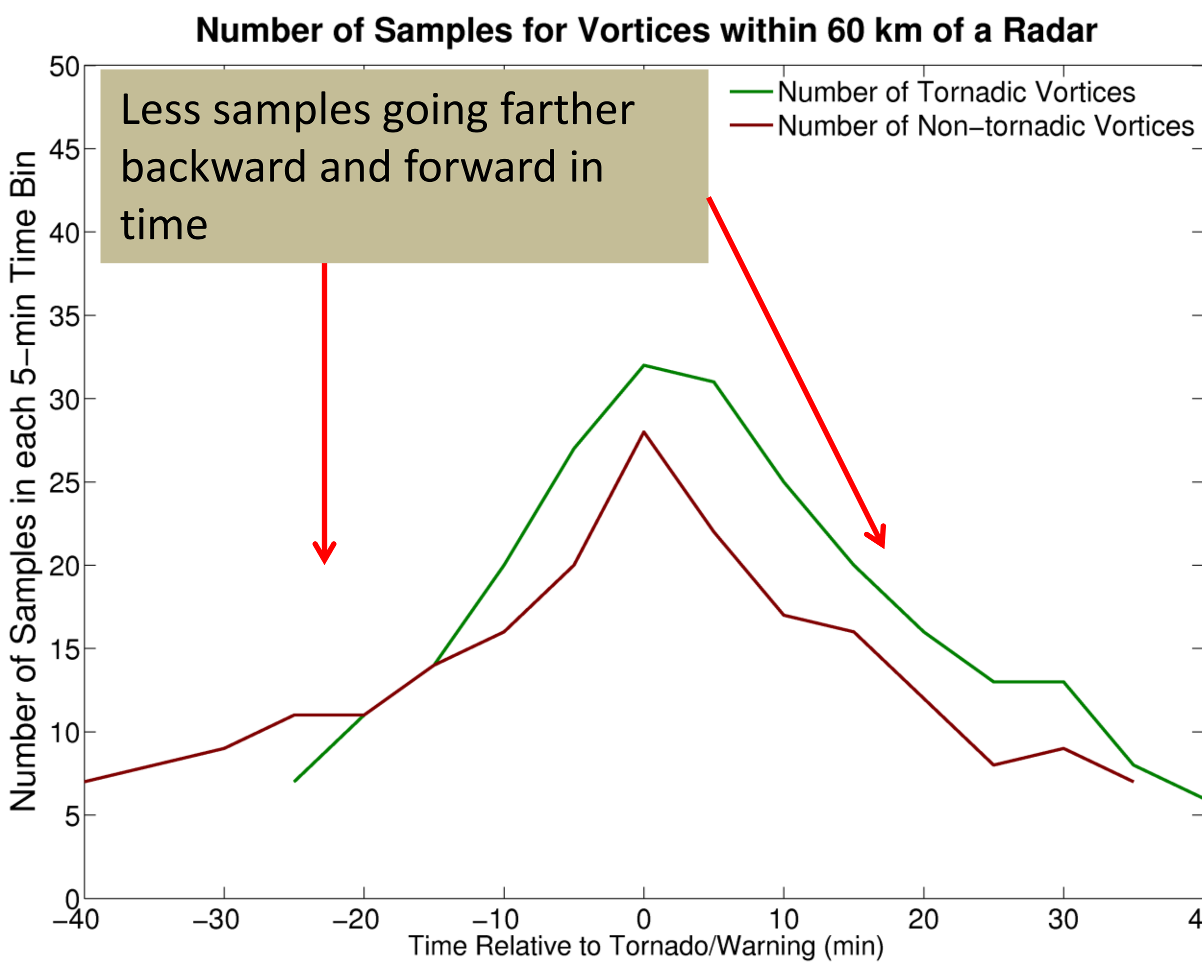
Azimuthal Shear Time Series Plots



Azimuthal Shear Time Series Plots

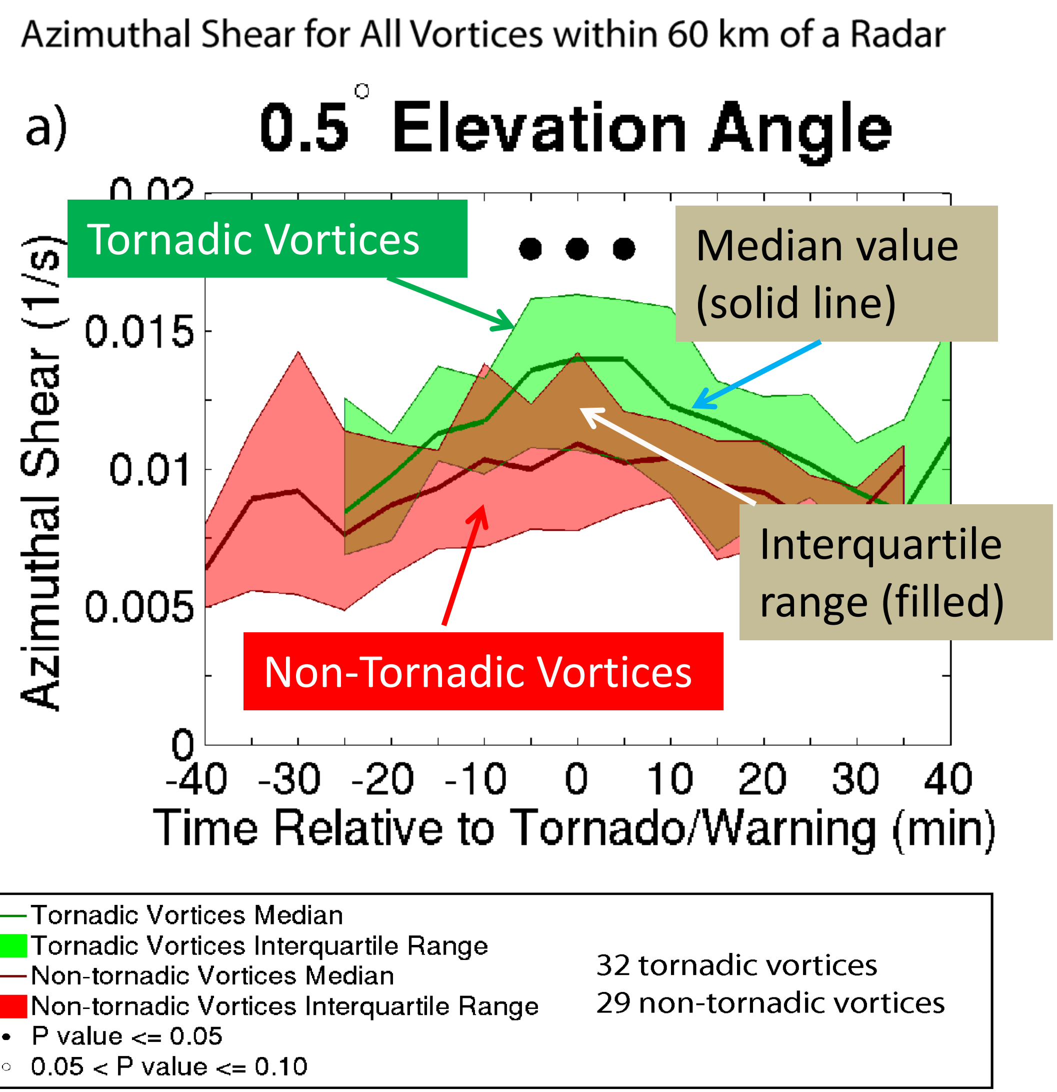


Azimuthal Shear Time Series Plots

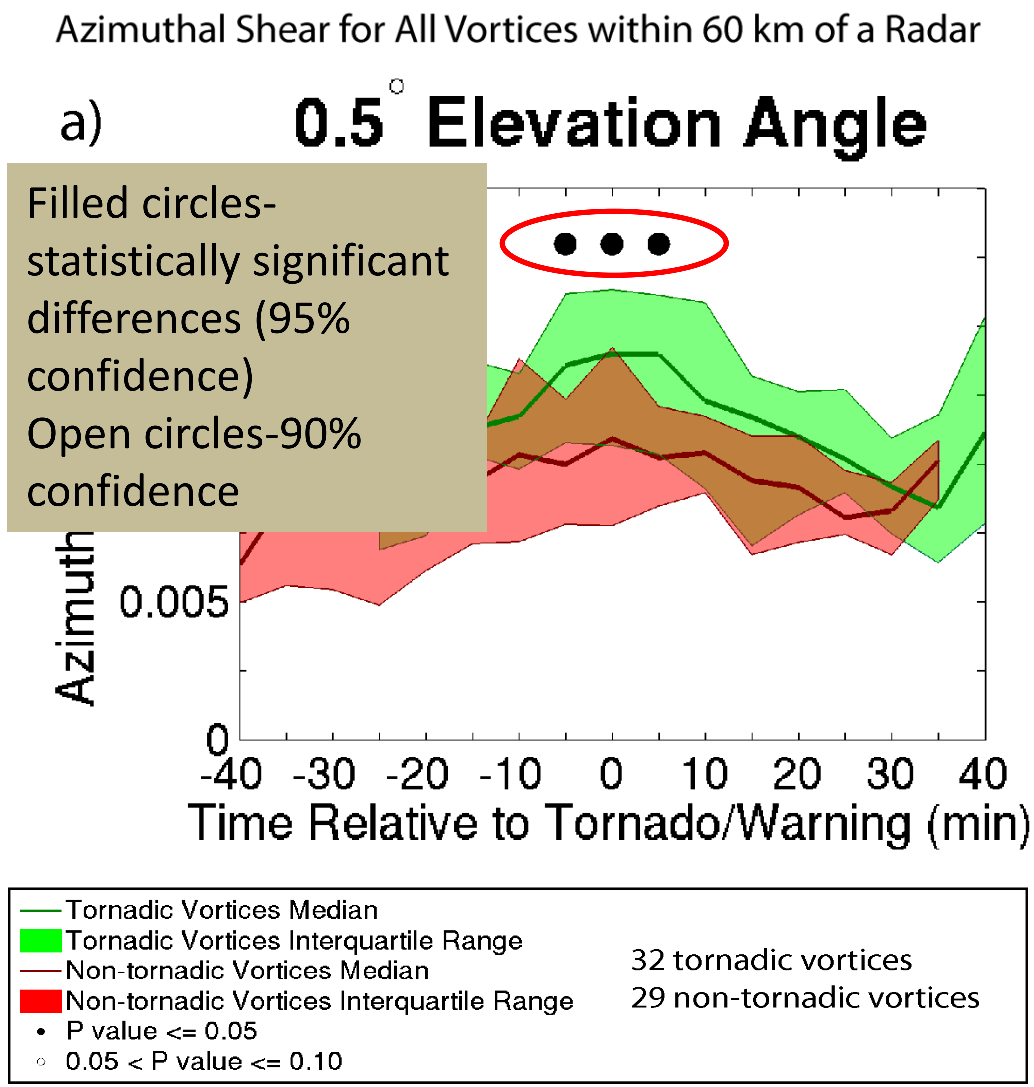


Azimuthal Shear Time Series Plots

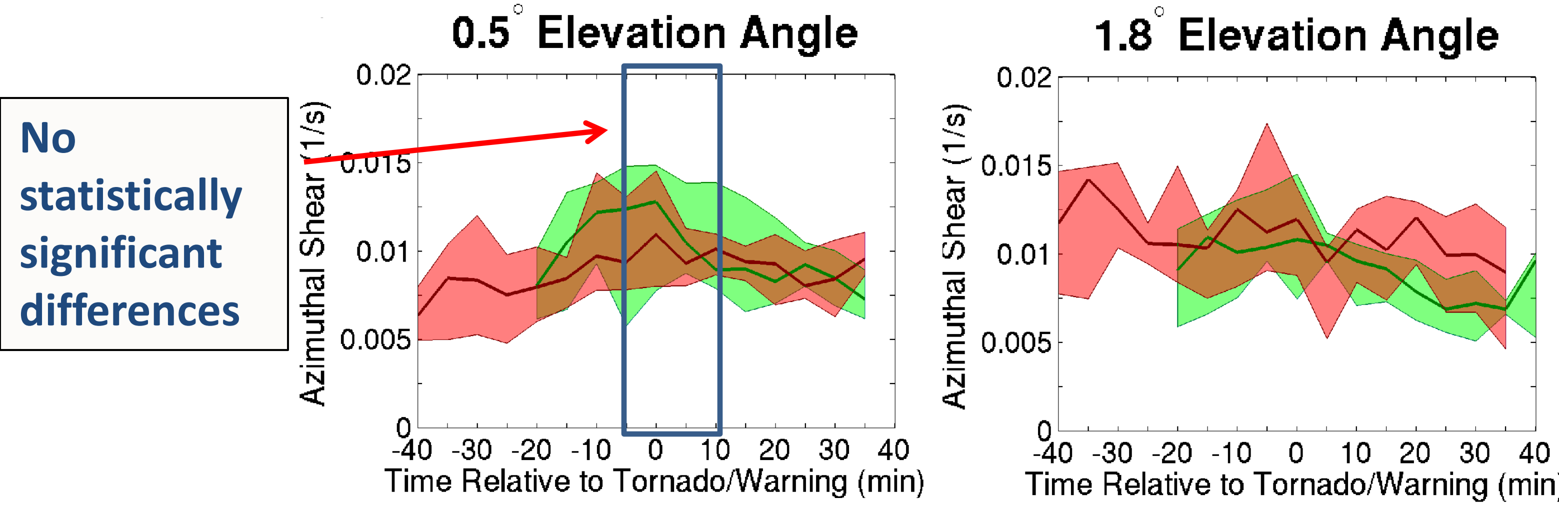
Data only plotted if at least 5 samples at that time



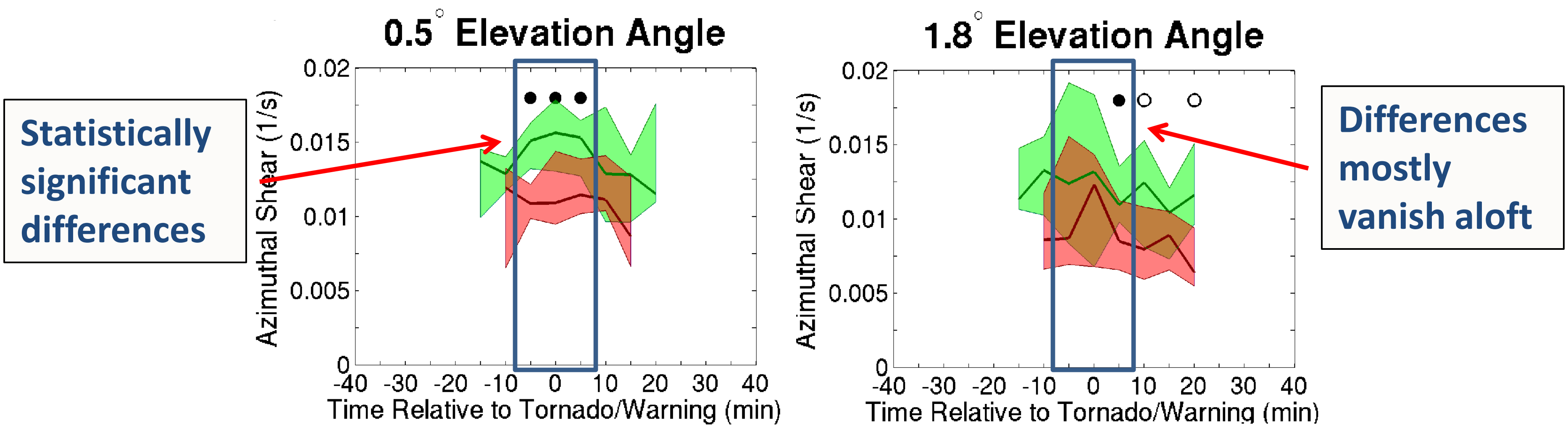
Azimuthal Shear Time Series Plots

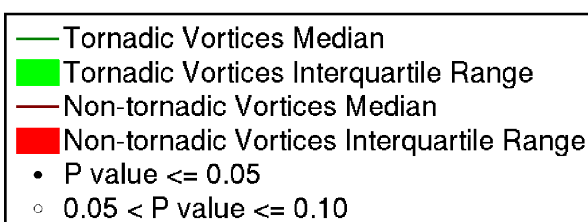


Supercell Mesocyclones (9 tor., 13 nontor.)



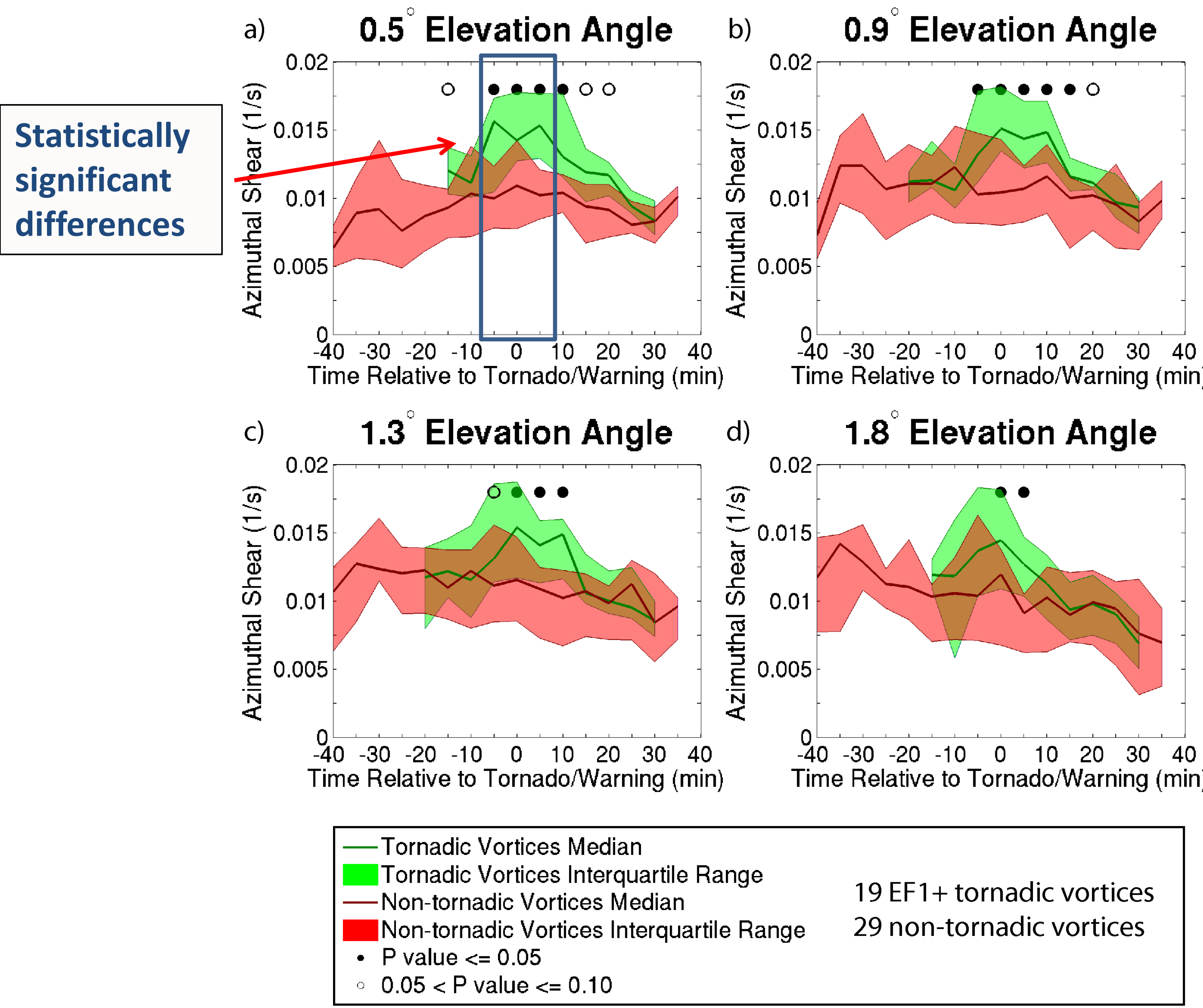
QLCS Mesovortices (17 tor., 12 nontor.)





Only vortices within 60 km of the radar

Azimuthal Shear for EF1+ Tornadoes within 60 km of a Radar

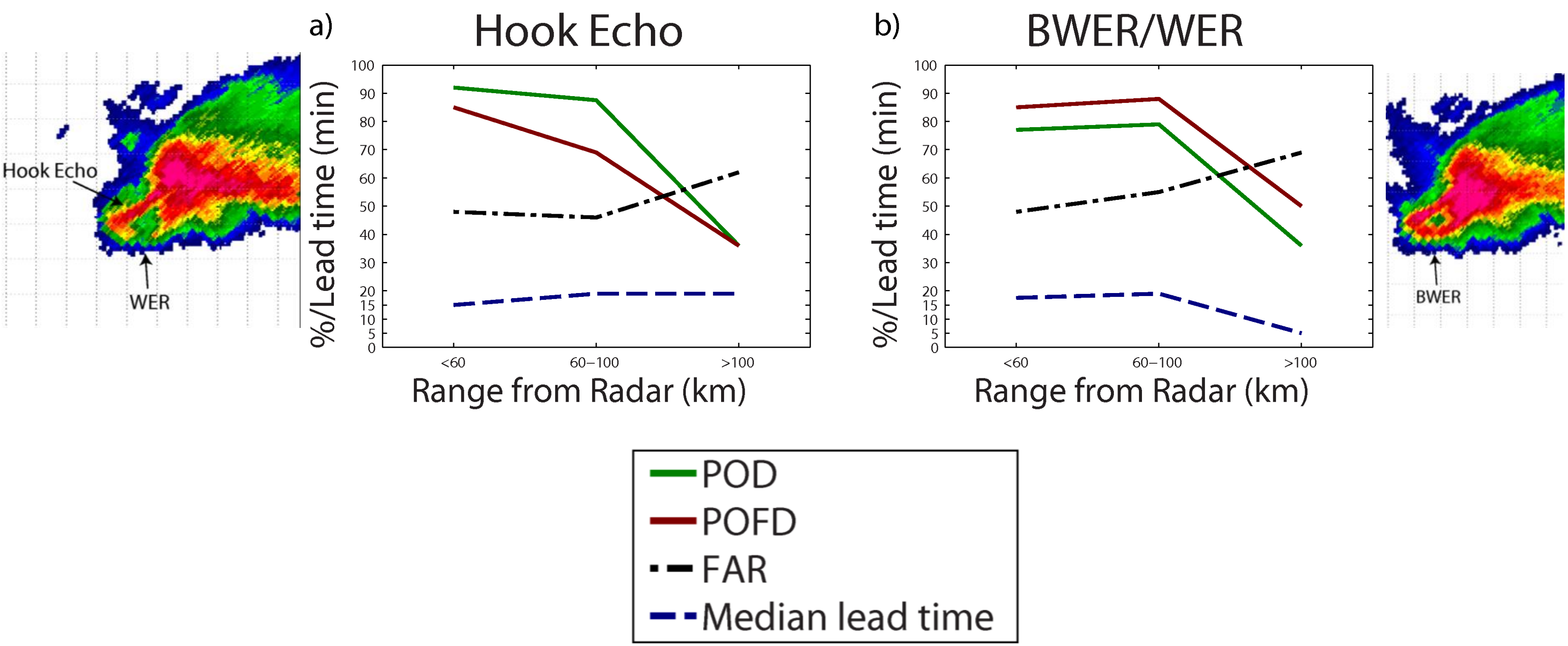


Reflectivity Signatures Climatology Methods

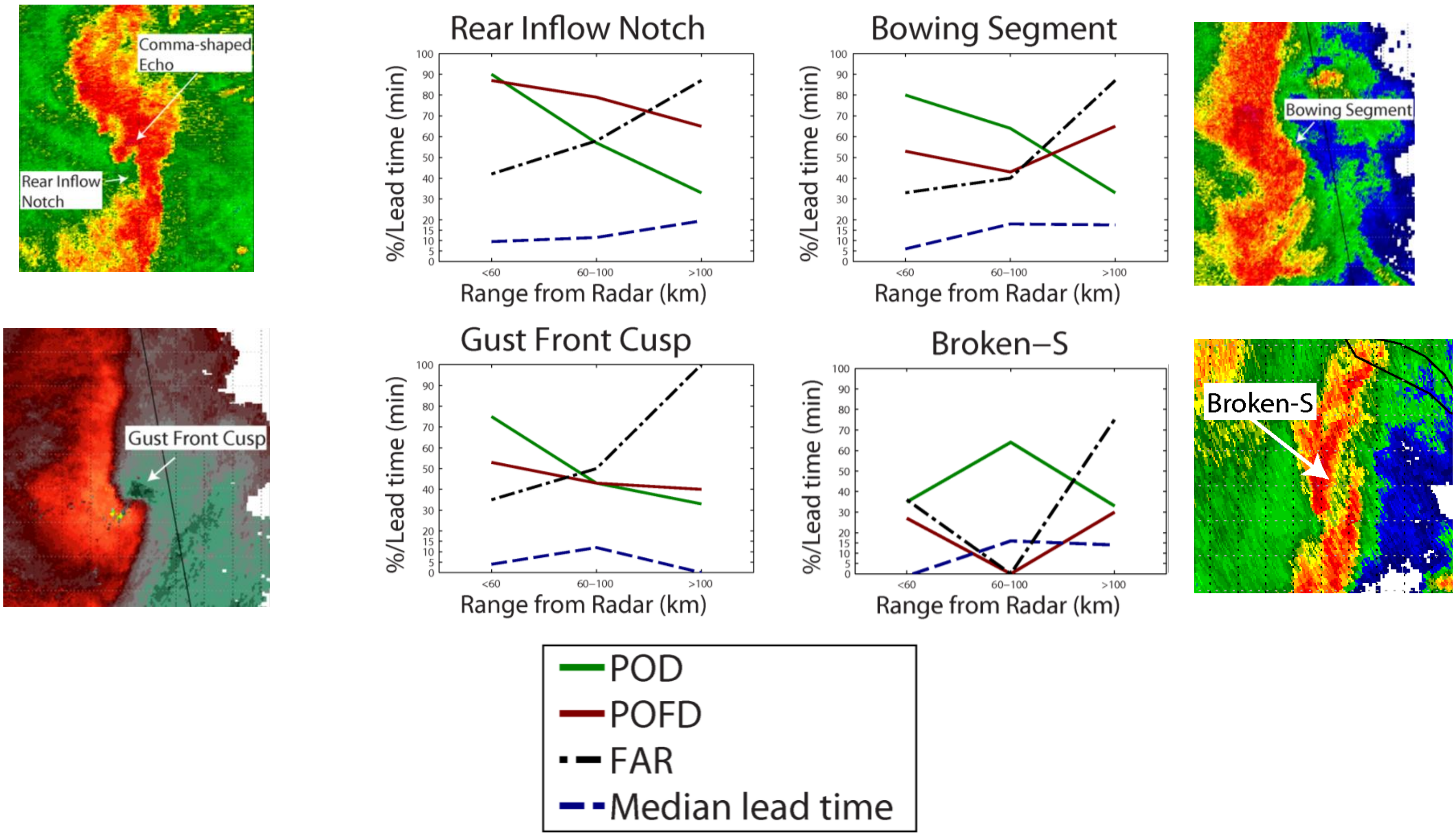
- Established criteria and manually identified reflectivity signatures associated w/ tornadic and non-tornadic vortices.

- Signatures identified within a window beginning 20 min prior to the tornado/TOR and ending 15 min after the tornado/TOR

Supercell Reflectivity Signatures



QLCS Reflectivity Signatures



HSLC CSTAR Project Take Aways

- HSLC severe convection is a forecast problem everywhere, but we have concentrated on the “low LCL” subset.

- SHERBS3 and SHERBE do not forecast the occurrence of convection but can forecast the significance of convection.

- The SHERBS3 and SHERBE improve on existing composite parameters in discriminating between HSLC significant severe convective and null environments.

- By focusing on lapse rates along with shear magnitudes, the SHERB uses the most skillful parameters and avoids the pitfalls of the “volatility” of CAPE calculations.

HSLC CSTAR Project Take Aways (continued)

- Azimuthal shear discriminates well between tornadic and non-tornadic vortices within 60 km of the radar, especially for QLCS mesovortices.

- Farther from the radar there is no difference in the magnitude of tornadic vs. non-tornadic vortices.

- There is the potential for longer lead times for supercell tornadic vortices.

HSLC CSTAR Project Take Aways (continued)

- Key reflectivity signatures have high POD, but also high FAR.
- Radar sampling properties are a critical factor in what forecasters “see”.
- Forecaster knowledge of typical diameter/altitude/intensity values of tornadic vortices allows for consideration of what will/won't be detectable at various ranges.
- Reflectivity, velocity, and environmental data should be utilized in conjunction for WDM purposes (no “silver bullet!”)

HSLC CSTAR Upcoming Articles

- Davis and Parker (2014), "Radar Climatology of Tornadic and Non-Tornadic Vortices in High-Shear, Low-CAPE Environments in the Mid-Atlantic and Southeastern U.S."

- Sherburn and Parker (2014), "Climatology and Ingredients of Significant Severe Convection in High Shear, Low CAPE Environments"

- Both recently **ACCEPTED** for publication in *Weather and Forecasting*

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- AMS/NASA Earth Science Graduate Fellowship Program
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- WFO Collaborators
- Storm Prediction Center

References

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- Dean, A. R., and R. S. Schneider, 2012: An examination of tornado environments, events, and impacts from 2003-2012. Preprints, *26th Conf. on Severe Local Storms*, Nashville, TN, Amer. Meteor. Soc., P60.

- Schneider, R. S., A. R. Dean, S. J. Weiss, and P. D. Bothwell, 2006: Analysis of estimated environments for 2004 and 2005 severe convective storm reports. Preprints, *23rd Conf. on Severe Local Storms*, St. Louis, MO, Amer. Meteor. Soc., 3.5.

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